

# Monitoring and predicting seasonal flight of *Orthosia hibisci* (Lepidoptera: Noctuidae) in the Okanagan and Similkameen Valleys of British Columbia

GARY J.R. JUDD, MARK G.T. GARDINER  
and DON R. THOMSON<sup>1</sup>

AGRICULTURE AND AGRI-FOOD CANADA, PACIFIC AGRI-FOOD  
RESEARCH CENTRE, SUMMERLAND, B.C. V0H 1Z0

## ABSTRACT

Seasonal flight activity of the speckled green fruitworm, *Orthosia hibisci* Guenée, was monitored from 1990 - 1993 with a commercial sex attractant in Pherocon 1-C sticky traps and UV light-traps hung in unsprayed apple orchards in the Okanagan (Summerland and Kelowna) and Similkameen Valleys (Cawston). Flights in the Similkameen began in late February each year but not before the second week of March in the Okanagan. Catches with sex attractant peaked around the end of March or early April in the Similkameen and peaked about 5 - 14 days later in the Okanagan. Males were caught earlier in light-traps than in sex-attractant traps, but females were caught in light traps about 6 days after the first males were caught with the sex-attractant. After this time lag, female catches in light traps paralleled male catches. Moths were caught in light traps for 1 - 2 weeks after catches with sex attractants had ended. Weibull functions were fitted to curves of cumulative percent catch with sex-attractant traps plotted against days or degree-days above 3°C air temperature ( $DD_{3^{\circ}C}$ ) using Summerland traps. Among models fitted to the Summerland data, one using  $DD_{3^{\circ}C}$  after 1 January was the best predictor of flight activity in Kelowna and Cawston, where the errors in predicting 50% catch were about 1 and 2 days, respectively. A model using the date of first catch in a sex-attractant trap to start DD summations, called the *biofix* because it serves as a biological indicator of moth activity, predicted 50% catch within 3 - 4 days. The biofix model is recommended because it provides biological realism and less chance for error in years with unusual weather conditions. Models fitted to 10 data sets combined, predict that 50% catch will occur 166  $DD_{3^{\circ}C}$  after 1 January, and 96  $DD_{3^{\circ}C}$  after biofix, respectively. These models should aid in timing pest control measures, especially biorational pesticides that require accurate information on insect phenology to be most effective.

**Key words:** *Orthosia hibisci*, green fruitworm, monitoring, flight activity, degree days, modelling.

## INTRODUCTION

The speckled green fruitworm, *Orthosia hibisci* Guenée, belongs to a North American complex of green fruitworms that feed on leaves and young fruits of many trees, including apple and pear (Chapman and Lienk 1974, Rings 1970). Although Madsen and Procter

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<sup>1</sup> **Current address:** Pacific Biocontrol Corp., Vancouver, WA, U.S.A.

(1985) never mentioned *O. hibisci* in their list of insects feeding on pome fruits in British Columbia, it is currently the most common green fruitworm pest in Okanagan and Similkameen orchards (Cossentine and Jensen 1995). *Orthosia hibisci* has one generation each year and overwinters as a pupa in the soil (Rings 1970). Adults emerge in early spring, eggs are thought to be laid shortly thereafter and young larvae begin to feed on apple buds in the tight-cluster stage (British Columbia Ministry of Agriculture, Fisheries and Food 1995). There are six larval instars and the later ones cause most of the damage to young fruit, but this depends on the phenology of fruit development (J.E. Cossentine, unpublished observations, Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, Summerland, B.C.).

Historically, green fruitworms have only been sporadic pests of pome fruits in British Columbia, because routine insecticide sprays for codling moth, *Cydia pomonella* (L.), control them (Madsen and Procter 1985). However, a recent sterile insect release (SIR) programme to eradicate codling moth from British Columbia's interior fruit-growing valleys (Dyck and Gardiner 1992), has forced changes to existing tree-fruit pest-management programmes. More damage from early season pests like *O. hibisci* and a greater need for specific controls of these pests is expected after the removal of insecticides aimed at codling moth (Judd and Gardiner 1992).

An ability to predict the seasonal flight activity of adult *O. hibisci* using traps and heat unit accumulation could be useful in designing an optimal control strategy. Although the life history of *O. hibisci* in British Columbia (Judd *et al.* 1994) is the same as reported by Rings (1970), its seasonal phenology is probably different. In New York (Weires *et al.* 1980) and Québec (Vincent and Simard 1986), adults apparently begin to emerge in late March or early April, respectively, and moths fly until late May, but moth activity has been seen as early as February in British Columbia (G.J.R.J. and D.R.T., unpublished data). Flight activity of adult *O. hibisci* can be monitored with attractant-baited traps (Lienk and Chapman 1978, Weires *et al.* 1980, Vincent and Simard 1986) or UV light traps (Paradis 1978) and Judd *et al.* (1994) provided a physiological basis for predicting development in overwintering pupae. Therefore, our objectives were: 1) to describe the seasonal flight activity of adult *O. hibisci* at three sites over four years by monitoring with a commercially available sex attractant and UV light-traps; 2) to compare and contrast the flight activity of males and females; 3) to describe the relationship between flight activity and temperature, and 4) to develop a method of predicting seasonal flight activity using this information.

## MATERIALS AND METHODS

*Monitoring Adult Flight Activity Patterns.* One certified commercial "organic" apple orchard at Cawston, 5 km south of Keremeos in the Similkameen Valley, and two unsprayed experimental apple blocks in the Okanagan Valley, one at the Agriculture Canada Research Centre in Summerland and the other at its Kelowna Substation, were used in this study. Two Pherocon 1-C style wing traps baited with commercial sex-attractant lures for *O. hibisci* (Ecogen, formerly Scentry<sup>®</sup>, Buckeye, Arizona, USA) were hung about 1.5 m above ground in the centre of each orchard-block. Monitoring began in mid-February each year (1990 - 1993) and continued until June. Lures were replaced at four-week intervals and the adhesive trap bottoms were replaced as required to avoid saturation with moth scales. At Summerland, traps were examined daily, whereas at Cawston and Kelowna, traps were examined weekly by one of us and daily by growers. Captured specimens were identified by wing patterns and genitalia. No other

lepidopteran species were caught in the sex-attractant-baited traps.

Flight activity of males and females was also monitored with UV light-traps placed approx. 20 m from the attractant-baited traps at the Cawston and Summerland sites. Light-traps were emptied daily at Summerland and weekly at Cawston. All moths were taken to the laboratory where they were frozen until sorted and sexed.

*Weather Data.* Hourly air temperatures were recorded throughout 1990 - 1993 at each site using two-channel DP-212 datapods (Omnidata Int., Logan, Utah) housed in Standard Stevenson screens placed in the centre of each orchard block. Daily degree-day (DD) summations for each site and year were calculated by fitting a sine wave (Allen 1976, case 4) to daily air-temperature minima and maxima using the computer program described by Higley *et al.* (1986). A developmental minimum temperature of 3°C was used in these calculations as this is the approximate threshold for pupal developmental (Judd *et al.* 1994). Although pupae overwinter in the soil, they do so near the surface (Judd *et al.* 1994), hence, air temperatures were found to be more useful than soil temperatures for predicting adult emergence (G.J.R.J., unpublished data). Air DD<sub>3°C</sub> summations were accumulated from 1 January until one week after the last moth had been caught at each site.

*Data Analyses.* As traps were only checked weekly at Cawston and Kelowna, all trap catches were summed over weekly intervals and plotted against days starting 1 January, the Julian date. Catches were also converted to percentages and cumulative percentages of seasonal total trap catches for each sex and trap-type for a given site and year, were plotted against Julian date. These sigmoid curves were rendered linear, by transforming percentages to probits (Finney 1971). Least-squares linear regression of probits on date was used to estimate the dates when chosen percentiles between 5 and 95% of the catch occurred; often these dates could not be identified exactly from a weekly sampling regime. All statistical calculations and tests were performed with SigmaStat™ Statistical Software (Version 1.0 for Windows, Jandel Corp.).

The nonlinear relationships between cumulative percentage trap catch and various predictor variables were also modelled with cumulative Weibull functions, which described the tails of the cumulative catch curves more accurately than linear regression. Often used to describe variation in insect development times (Wagner *et al.* 1984), this function can also be used to describe the relationship between cumulative trap catches and time or temperature (Cockfield *et al.* 1994). A cumulative Weibull function in the form,

$$f(X) = 100 \times \left( 1 - e^{-\left(\frac{x}{a}\right)^b} \right)$$

was used to describe or model the curves of cumulative catches, where  $f(X)$  is the cumulative percentage trap catch,  $x$  is a chosen predictor variable, and  $a$  and  $b$  are parameters that define the shape of the distribution. Estimated values for the parameters defining each cumulative distribution or curve were calculated using the nonlinear regression procedure in SigmaStat™.

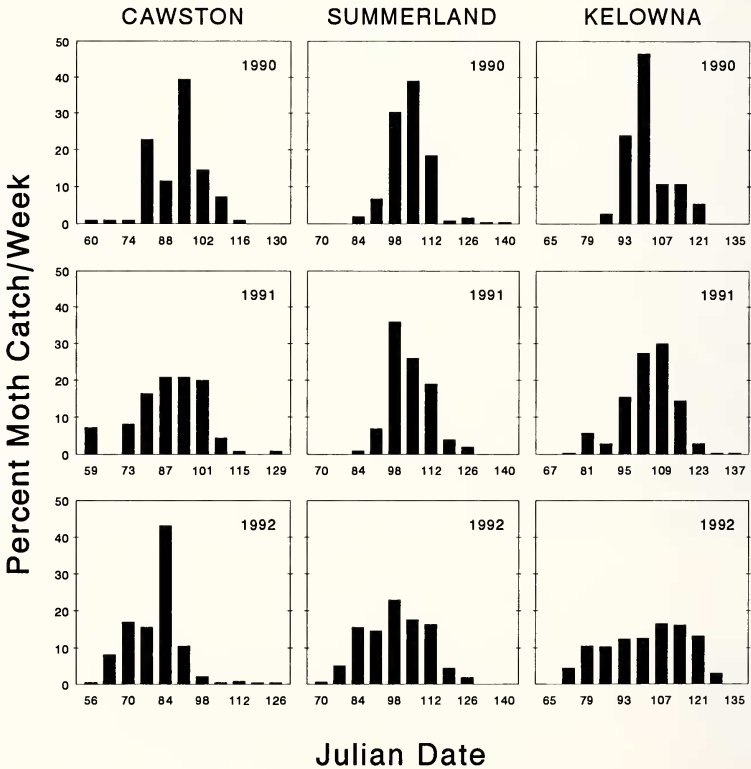
Predictive models of cumulative moth catch in relation to days and DD<sub>3°C</sub> were developed using sex-attractant trap catches at Summerland (1990 - 1993). Two starting dates for initiating accumulations of days and DD were chosen: 1) 1 January was chosen as a convenient but arbitrary chronological start to a new season, and 2) first catch in a sex-attractant trap, hereafter referred to as the *biofix*, was chosen as an identifiable biological reference point for the beginning of emergence of this insect. First trap catch using pheromones is a convenient method of incorporating biological realism into insect phenology models that has proven useful in predicting seasonal activity of other pests of

tree-fruit crops (Reidl *et al.* 1976).

Four model combinations (1 January start using days or DD, and a biofix start using days or DD) were used to predict cumulative catch curves for sex-attractant traps monitored in Kelowna (1990 - 1992) and Cawston (1990, 1992 and 1993) using weather data from the respective sites. Due to an equipment failure there were no weather data from Cawston in 1991. The observed dates for 50% catch at Cawston and Kelowna, as estimated from probit regression lines, were compared with the predicted values from the Weibull models fitted to Summerland data. A paired-sample *t*-test ( $\alpha = 0.05\%$ ) was used to test the null hypothesis that the mean deviations between observed and predicted values were zero (Zar 1984).

### RESULTS AND DISCUSSION

*Seasonal Flight Activity Determined with Sex-attractant Traps.* Weekly catches of male *O. hibisci* in sex-attractant traps showed significant differences in the start of flight among Cawston, Summerland and Kelowna populations during 1990 - 1992 (Fig. 1).



**Figure 1.** Weekly percentages of total catches of male *O. hibisci* in sex-attractant-baited Pherocon 1-C traps during 1990-1992 at Cawston, Summerland and Kelowna. Julian date = days from 1 January. Totals caught in 1990, 1991 and 1992, respectively, were: Cawston 96, 110, 216; Summerland 253, 95, 305; and Kelowna 75, 310, 480.

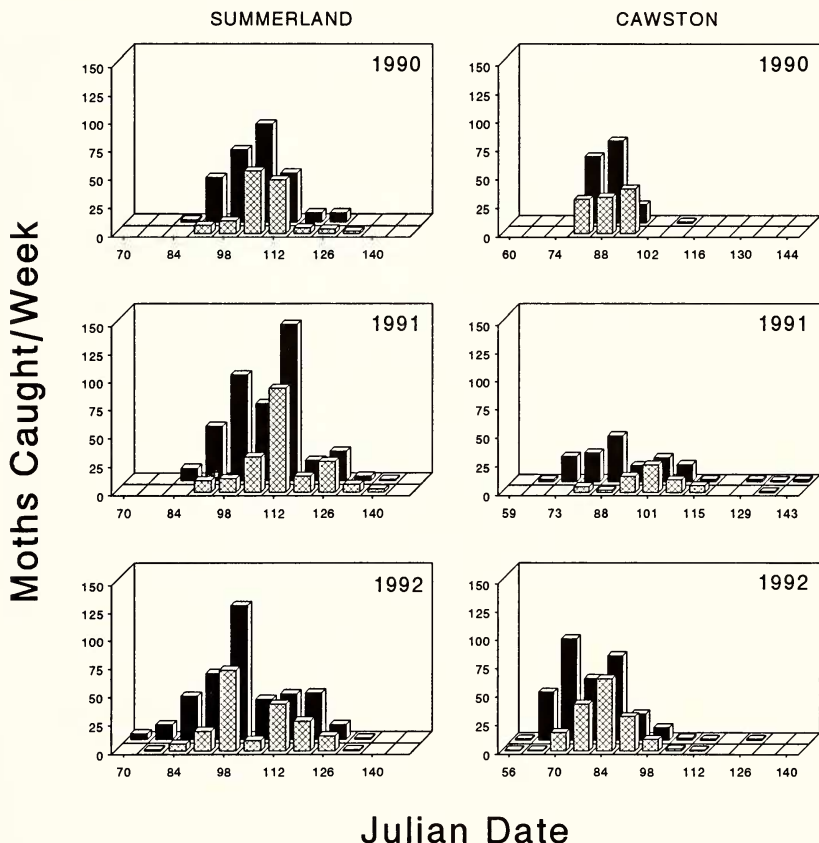
Flight activity in Cawston began in the last week of February or about 50-60 days after 1 January each year, while flights in Summerland and Kelowna never started before the second week of March, about 75 days after 1 January. Located in the Similkameen Valley,



Cawston is the most south western location in this study and generally accumulates heat units earlier than sites in the Okanagan Valley (Judd and McBrien 1994).

At all sites and in most years, catches with the sex-attractant traps had a single well defined peak as reported in Québec (Vincent and Simard 1986), but occasionally curves were flattened and skewed (eg. Kelowna 1992). Differences in flight activity among sites were less pronounced as the flights reached their peaks, usually in late March or early April (Fig. 1). Catches in Cawston usually peaked 5 - 14 days earlier than at Summerland or Kelowna. Flight activity of *O. hibisci* in the Okanagan and Similkameen Valleys began about 32 and 75 days earlier than the first captures in New York and Québec, respectively (Weirs *et al.* 1980, Vincent and Simard 1986). Cumulative catches in Pherocon 1-C traps during each year of this study were also higher in British Columbia than those reported for Québec (Vincent and Simard 1986).

*Comparison of Male and Female Flight Activity.* In contrast to studies in Québec (Paradis 1978), males were twice as abundant as females in light traps (Fig. 2).



**Figure 2.** Mean weekly catches of male (solid bars) and female (hatched bars) *O. hibisci* in UV light-traps during 1990-1992 at Summerland and Cawston. Julian date = days from 1 January. Total moths (male:female) caught in 1990, 1991 and 1992, respectively were: Cawston 147:101, 146:63, 298:165 and Summerland 242:131, 409:196, 363:185.

Weekly catches in UV light-traps at Cawston and Summerland may indicate that *O. hibisci* is protandrous (Fig. 2), with males being caught about 11 days before females (Table 1). Protandry was not evident among adults emerging from field-collected pupae

held in the laboratory (Judd *et al.* 1994), but could arise from sex-related differences in depths of overwintering sites, or when diapause ends. However, differences in trap catches may simply reflect sex-related differences in adult maturation rates or flight behaviour. As light-trap catches of both sexes usually peaked and ended on the same date in each site (Table 1), a later emergence of females would mean that females have a shorter flight activity period than males.

*Phenology of Flight Using Sex-attractant and Light-trap Catches.* At Summerland, where traps were examined daily and first-trap catches could be identified exactly, first catches of males in light traps preceded catches in attractant traps by about 2 days (Table 1). First catches of females in light traps occurred about 9 days after the first males were caught in attractant traps and this difference in cumulative catches remained constant at least half way through the flight (Table 1). Different phenological patterns produced by these different traps may result from differences in their relative attractiveness. Generally it is assumed that light-traps capture a more local population than do sex-attractant traps because attractants carried on the wind can attract males from hundreds of metres (Wall and Perry 1984), whereas light traps may only be visible over a few metres. In fact, capture of males in attractant traps before emergence is expected, is often explained as the attraction of males from warmer microenvironments outside the local area where emergence was confirmed by other means (Reidl *et al.* 1976). If light traps catch the earliest locally emerging moths then later first catches in attractant traps, may indicate that the response of male *O. hibisci* to sex attractants under the prevailing conditions was delayed for at least a few days after emergence. If males emerge first, they may disperse for some time during which they do not respond to sex attractants, but do respond to light-traps, explaining their earlier capture in light traps (Table 1). Such a delay might increase outbreeding as it would allow males to disperse from their sisters before searching for mates. To answer this question more work is needed to establish the relationship between trap catches and actual emergence.

Differences in phenological events as measured by the different traps were less pronounced during the middle and peak periods (50%) of flight activity (Table 1). Catch curves for light-traps tended to have longer tails than those for the sex-attractant traps, often not reaching the 95th percentile until days or weeks after the sex-attractant traps (Fig. 2; Table 1). This may indicate that older adults, past their peak reproductive phase, are attracted to light-traps after mating opportunities have declined, along with responses to sex attractants. For this reason, sex-attractant traps probably detect local mating populations better, and may be more useful for integrated pest management in tree fruits. Although twice as many males were caught in light-traps, they required much more laborious and time consuming sorting. Although not identified as a pheromone, the commercial sex-attractant acted quite specifically in our geographic region. We agree with Vincent and Simard (1986) that sex-attractant traps are a useful method of monitoring seasonal flight activity of *O. hibisci*.

We also conclude that despite a time lag in capture rates, male catches in attractant traps could be used to estimate flight patterns of females, at least in the first half of the season. While the intercepts of linear regression lines for catch curves of each sex at a given site were different, their slopes were similar and parallel (*t*-tests,  $p > 0.05$ ).

*Day and Degree-Day Indices for Flight Curves.* Differences in dates of first capture accounted for much of the yearly and geographic differences between the flight-activity curves generated by the two types of traps (Table 1; Figs. 1,2). However, after the first catch, the number of days to various catch percentiles was similar among years. At Summerland, dates of first, 5, 50 and 95% capture in sex-attractant traps and days

**Table 1.** Observed day and degree-day (DD) summations from 1 January to various trapping events for *Orthosia hibisci* during 1990 - 1993 at Summerland using sex attractant (ST) and UV light-traps (LT).

Statistic <sup>a</sup>	First trap catch			50% cumulative catch			50% cumulative catch			95% cumulative catch			
	ST	LT	♀ ♀	ST	LT	♂ ♂	ST	LT	♂ ♂	ST	LT	♂ ♂	♀ ♀
Median	80	78	89	89	89	89	99	100	100	112	118	118	120
$\bar{x}$	77.7	74.3	83.7	84.7	85	89.3	97.7	99.3	99.3	111	118.7	118.7	121.7
SD	7.7	9.1	10.1	8.4	6.9	2.9	3.2	5.0	6.1	2.6	2.1	3.1	3.1
C.V.	9.9	12.2	12.1	9.9	8.1	3.2	3.3	5.1	5.9	2.4	1.7	2.5	2.5
						<b>DD<sup>b</sup></b>							
Median	89.1	79.4	111.3	114.6	107.6	123.1	181.3	181.3	181.3	243	311.1	311.1	343.5
$\bar{x}$	87.4	79.4	111.3	115.2	116.4	141.2	186.5	195.0	216.1	272.5	327.1	350.4	350.4
SD	11.4	4.9	3.7	10.1	17.1	31.8	34.8	24.8	13.7	51.5	36.5	36.5	36.1
C.V.	13.0	6.2	3.3	8.7	14.7	22.5	18.6	12.7	6.4	18.9	11.1	11.1	10.3

<sup>a</sup>SD = Standard Deviation and C.V. = Coefficient of variation

<sup>b</sup>Degree days above 3°C air temperature

between these events, generally had smaller standard deviations (SD) and coefficients of variation (C.V.) than did the DD accumulations for the same events (Table 1). Nonlinear regression models confirmed this and based on  $r^2$  values and standard errors (SE's) of regression coefficients, both days starting 1 January and days after biofix described flight curves at Summerland somewhat more accurately than DD after 1 January or biofix, respectively (Table 2). According to the fitted models (Table 2), on average 50% catch should occur on day 100 of the year, 19 days after biofix, or 170 DD starting 1 January, 86 DD after biofix.

**Table 2.**

Estimated values for parameters of Weibull functions and their goodness of fit to cumulative percent catch in sex attractant traps at Summerland (1990 - 1993) using different predictor variables and model starting dates.

Predictor variable	Model started	Weibull parameter	Estimated values ( $\pm$ SE)	Model SE	$r^2$ ( $p$ value)
Days	1 January	a	101.92 $\pm$ 0.45	6.05	0.98 (0.001)
		b	14.21 $\pm$ 1.05		
	First catch	a	21.66 $\pm$ 0.88	10.21	0.94 (0.001)
		b	2.17 $\pm$ 0.27		
Degree Days <sup>a</sup>	1 January	a	192.59 $\pm$ 10.09	18.33	0.82 (0.001)
		b	2.97 $\pm$ 0.56		
	First catch	a	105.89 $\pm$ 5.67	10.99	0.93 (0.001)
		b	1.77 $\pm$ 0.23		

<sup>a</sup>Degree days above 3°C air temperature

*Predicting Seasonal Flight Activity.* The accuracy of these different models was tested by using them to predict flight activity curves for independent data sets from Cawston and Kelowna. Using days starting 1 January the Summerland model predicted 50% catch, 7 - 22 days after it occurred at Cawston, but the prediction error ranged from 2 days early to 3 days late at Kelowna. Greater accuracy at Kelowna is not unexpected because catches at Summerland and Kelowna were similar and always began several days later than at Cawston (Figs. 1, 2). Use of a first-catch biofix, with days as a predictor variable resulted in early, but similar predictions for both Cawston and Kelowna (Table 3). The reason for these early predictions probably arises because catch curves at Cawston and Kelowna were more skewed than at Summerland (Fig. 1), meaning that while biofix may have occurred on a similar date in some cases, it took less time for catches to reach 50% at Summerland, hence the early predictions.

Generally, prediction errors based on DD were smaller than corresponding predictions based on days (Table 3) and the errors in prediction were similar in magnitude, and consistently biased in the same direction for Cawston and Kelowna. If the underlying assumption that flight activity can be modelled by temperature and DD is correct, then this similarity in errors is expected. Differences in the rates of DD accumulation at different sites as a result of altitude, slope and aspect are taken into account, whereas models based on date alone do not do this. However, models based on days are useful when weather data is not available or is inaccurate. If the difference between two sites is



**Table 3.** Deviation between observed and predicted days from 1 January to 50% cumulative catch in sex-attractant traps at different locations and years using different predictor variables and model starting dates for prediction models based on Weibull functions fitted to Summerland data (1990 - 1993).

Model started	Location	Year	Observed days from and including start date	Predicted days from start date using days or DD as predictor variables		Mean error of prediction ( $\pm$ SD) in days using days or DD as predictor variables <sup>a</sup>	
				Days	DD	Days	DD
1 January	Cawston	1990	90	100	90		
		1992	78	100	75	-13.0 $\pm$ 7.9	1.7 $\pm$ 5.7
		1993	93	100	101		
	Kelowna	1990	97	100	101		
		1991	102	100	107	-0.3 $\pm$ 2.5	-1.3 $\pm$ 7.2
		1992	100	100	91		
				Grand $\bar{x}$	-6.7 $\pm$ 8.7 ns	-1.5 $\pm$ 5.8ns	
First catch	Cawston	1990	90	79	85		
		1992	78	74	76	-6.0 $\pm$ 4.4	-4.3 $\pm$ 2.1
		1993	93	90	87		
	Kelowna	1990	97	97	97		
		1991	102	92	101	-6.7 $\pm$ 5.8	-3.0 $\pm$ 4.4
		1992	100	90	92		
				Grand $\bar{x}$	6.3 $\pm$ 4.6*	3.7 $\pm$ 3.1*	

<sup>a</sup> Significance level for paired comparisons (Paired t-test,  $\alpha = 0.05$ ) between grand means of observed and predicted dates indicated by: ns =  $p > 0.05$ ; \* =  $p < 0.05$

known, then traps monitored at Summerland could be used to predict flights in orchards in the Similkameen Valley or other regions of the Okanagan by simply adding or subtracting an appropriate number of days

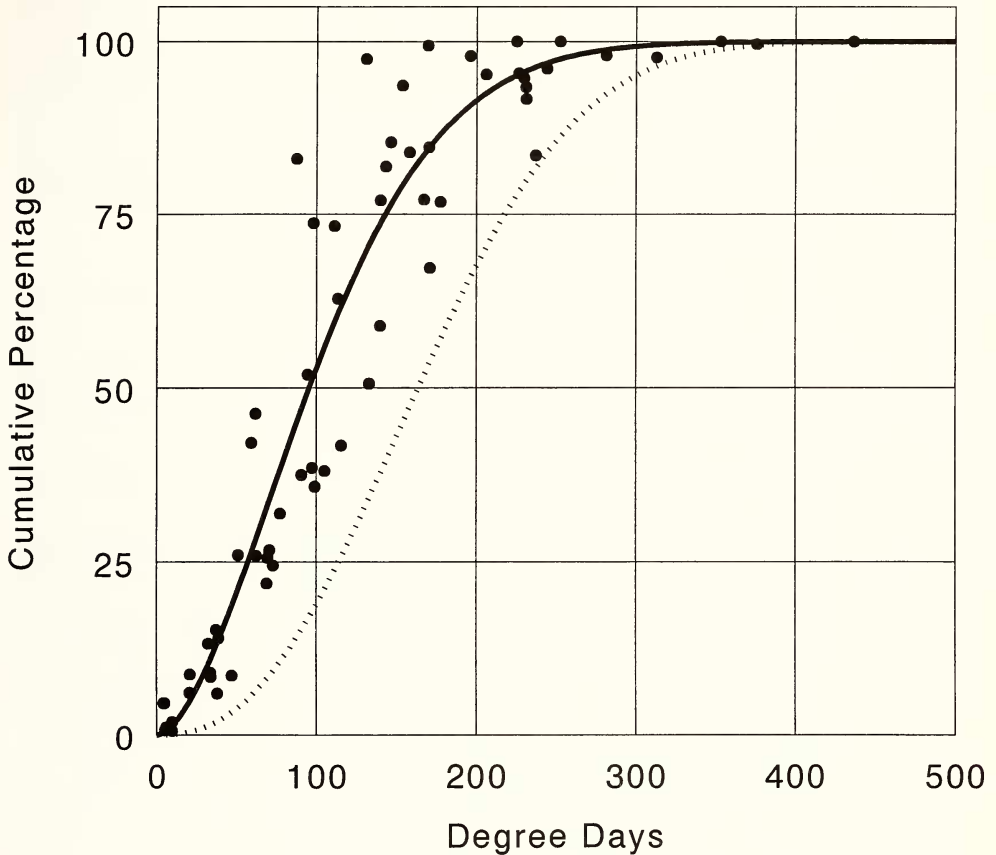
Calculating the mean error of prediction by taking the signs into account (- being early and + being late predictions, respectively), then a model using DD starting 1 January was the most accurate predictor of 50% catch at all sites combined (Table 3). The mean deviations based on 1 January were not significantly different from zero, while those based on a biofix were (Table 3). This is somewhat misleading because predictions based on a biofix had smaller SD's than those based on 1 January, which probably contributed to the paired *t*-test being significant (Zar 1984). Ignoring the sign of the prediction errors and using absolute deviations, predictions based on DD in conjunction with a biofix provided slightly more accurate predictions with a smaller SE. Given that initiation of flight was the most significant difference among catch curves at different sites (Fig. 1), it was surprising to find that predictions based on a biofix were only marginally better than those using 1 January (Table 3). One obvious source of error were the dates of first catch at Kelowna and Cawston, which were not known with certainty, as they were at Summerland. Another reason may be that unlike some other species (eg. codling moth), biofix for *O. hibisci* occurs very early in the season before errors in DD calculation can accumulate.

Having shown that DD are slightly more accurate than days at predicting flight activity, we combined the sex-attractant trap-catch data from all sites and years (10 data sets), and fitted Weibull functions using DD from both 1 January and biofix. The model based on 1 January ( $a = 190.53$ ,  $b = 2.43$ ) had a SE of 16.57 and an  $r^2$  of 0.79, while the model based on a biofix ( $a = 118.39$ ,  $b = 1.72$ ) had a SE of 11.04 and an  $r^2$  of 0.91. There is little difference between the  $r^2$  values, regression coefficients, or the SE's of these models based on the complete data set and those using the partial data set (Table 2). Based on this analysis a model using DD with a biofix can probably be recommended over using 1 January only. While it appears possible to predict catch curves using 1 January as a starting date for DD accumulations (Table 3), this might introduce potential errors that could be eliminated by using traps to establish a site-specific annual biofix. We recommend using a biofix to start DD summation, but if this is not available, as is sometimes the case, DD from 1 January can be used.

A scatter of the relationships between DD after biofix and cumulative catches at all sites and years (complete data set) and a fitted Weibull function are shown in Fig. 3. This plot contains more scatter than a similar plot for Summerland only (partial data set), but a model based on the entire data set should be more robust than the partial model. The former model would provide the most accurate table of catch percentiles on which to base spray recommendations. For comparison, a curve fitted to the complete data set using DD after 1 January is also shown in Fig. 3, but the data points were excluded for clarity. Curves fitted to the complete data set (Fig. 3) predict that on average, 50% of the moths will be caught 166 DD after 1 January and 96 DD after biofix.

Apple and pear growers in British Columbia's interior fruit-growing regions are attempting to benefit economically from the codling moth SIR programme by growing and marketing insecticide-free fruit. To achieve this objective, growers must not use conventional synthetic insecticides after apple and pear trees bloom. Pest management experts would like to recommend greater use of biorational pesticides (eg. Dipel<sup>®</sup> or Confirm<sup>®</sup>) against secondary pests like *O. hibisci*. These must be applied at optimal times because many are most effective against specific larval instars (Charmillot 1994a,b). Poor timing will reduce the efficacy of biorational insecticides and growers will be reluctant to

use them in their pest management programmes, especially if they are more expensive; to be effective the target insects' phenology must be known or accurately predicted.



**Figure 3.** Cumulative catches of males (circles) in sex-attractant traps at Cawston (1990, 1992, 1993), Summerland (1990-1993) and Kelowna (1990-1992) plotted against cumulative degree days (DD) above 3°C after first trap catch (biofix). Solid line - a Weibull function fitted to these points, dotted line - a Weibull function fitted to a similar scatter (not shown for clarity) of same data plotted against cumulative DD after 1 January.

Our data show that for *O. hibisci*, DD after first catch in a sex-attractant trap is a good predictor of adult flight activity in the interior of British Columbia. Prediction of dates of peak or 50% cumulative catch using this model should be useful for timing controls, but any percentile can be predicted. To make better use of this model in timing controls against *O. hibisci*, further study is needed to describe the relationship between male flight activity, as measured by sex-attractant traps, and female emergence and oviposition.

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